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冰川均衡调整对南极冰质量平衡监测的影响及其不确定性

贾路路[1,2], 汪汉胜[1], 相龙伟[1,2], WU Patrick[3], 李斐[4], 史红岭[1,2]*

1. 中国科学院测量与地球物理研究所动力大地测量学重点实验室,武汉 430077;
2. 中国科学院研究生院,北京 100049;
3. Department of Geoscience, University of Calgary, Calgary T2N 1N4, Canada;
4. 中国南极测绘研究中心,武汉 430079

Effects of glacial isostatic adjustment on the estimate of ice mass balance over Antarctica and the uncertainties

JIA Lu-Lu[1,2], WANG Han-Sheng[1], XIANG Long-Wei[1,2], WU Patrick[3], LI Fei[4], SHI Hong-Ling[1,2]*

1. Key Laboratory of Dynamical Geodesy, Institute of Geodesy and Geophysics, Chinese Academy of Sciences, Wuhan 430077, China;
2. Graduate University of Chinese Academy of Sciences, Beijing 100049, China;
3. Department of Geoscience, University of Calgary, Calgary T2N 1N4, Canada;
4. Chinese Antarctic Center of Surveying and Mapping, Wuhan 430079, China

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摘要 本文研究了新的全球冰川均衡调整(GIA)模型对南极冰盖质量平衡监测的影响,考虑现有冰川负荷模型和地幔黏滞度模型的差异,完整评估了结果的不确定性,最后结合GRACE和卫星测高的结果进行了对比分析.结果表明,GIA对GRACE监测的等效水柱变化有重大影响,较大的GIA影响出现在西南极,沿罗斯冰架-卡姆布冰流-罗尼冰架-南极半岛分布,最大值在卡姆布冰流,达到29.8 mm/a;GIA对南极整体冰质量平衡的影响达到134±28 Gt/a.在不确定性的方差中,西南极和东南极分别以冰负荷模型差异和地幔黏滞度差异影响为主,对整个南极,冰模型差异影响占88.4%;在一些典型地区,GRACE监测的等效水柱在扣除GIA前后分别是,卡姆布冰流~32.8 mm/a和~6.3 mm/a,阿蒙森海湾~-95.3 mm/a和~-102.5 mm/a,Enderby Land~13.6 mm/a和~8.1 mm/a.整个南极冰盖总质量变化在扣除GIA贡献后为-82±29 Gt/a,该估计与卫星测高结果较吻合.此外,GIA对卫星测高监测的冰面高程变化的影响一般不超过8%.本研究为空间大地测量监测南极冰质量平衡提供了新的改正模型.

关键词: 冰川均衡调整 地幔黏滞度 空间大地测量 南极 冰质量平衡

Abstract: The effects of glacial isostatic adjustment (GIA) on monitoring ice mass balance over Antarctica are investigated using our newly-released GIA model ICE-4G+RF3L20(β=0.4) and the uncertainties are evaluated by considering the effects of differences in ice load models and reference mantle viscosities. The results and the comparison with those from GRACE time-varying gravity fields and satellite altimetry data are shown as follows. It is found that the GIA has strong effects on monitoring the changes of equivalent water height (EWH) from GRACE gravity data, significant GIA effects occur at Ross Ice Shelf, Kamb Ice Stream, Ronne Ice Shelf and Antarctic Peninsula with a maximal magnitude of ~29.8 mm/a at Kamb Ice Stream. For the whole Antarctica, the effect of GIA on total ice mass balance is 134±28 Gt/a. The differences in ice models account for 88.4% of the variances of uncertainties while the differences in viscosity models contribute 11.6%. In some typical regions, the changes of EWH monitored by GRACE data are given before and after GIA corrections. These are ~32.8 mm/a and ~6.3 mm/a for Kamb Ice Stream, ~-95.3 mm/a and ~-102.5 mm/a for Amundsen Sea Embayment, ~13.6 mm/a and ~8.1 mm/a for Enderby Land. The total ice mass change of the whole Antarctica is found to be -82±29 Gt/a after GIA corrections which is quite close to that estimated from satellite altimetry data. Furthermore, the effects of GIA on the ice height changes observed from ICESat are less than 8%. The results related to our new GIA model in this paper can be utilized to precisely monitor the present ice mass balance in Antarctica from space geodetic techniques.

Keywords: Glacial isostatic adjustment Mantle viscosity Space geodesy Antarctica Ice mass balance

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Corresponding Authors: 汪汉胜,男,1964年生,研究员,1984年毕业于武汉地质学院物探系,1999年获中国科学院测量与地球物理研究所博士学位,主要从事冰川均衡调整、地球负荷问题等研究.E-mail:whs@asch.whigg.ac.cn Email: whs@asch.whigg.ac.cn

About author: 贾路路,男,1984年生,博士研究生,主要从事卫星重力场解释和冰川均衡调整的研究.E-mail:iceagejia@163.com